ARMY
PROPOSAL SUBMITTAL

The United States Army Research Office (ARO, reporting to the Army Research Laboratory ARL) manages the Army's Small Business Technology Transfer (STTR) activity. The following pages list topics that have been approved for the fiscal year 2001 STTR program. Proposals addressing these areas will be accepted for consideration if they are received no later than the closing date and hour of this solicitation. Such proposals may be submitted to ARO at either its physical address or its postal address:

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The Army anticipates funding sufficient to award one or two STTR Phase I contracts to small businesses with their partner research organizations in each topic area. Awards will be made on the basis of technical evaluations using the criteria contained in the solicitation, within the bounds of STTR funds available to the Army. If no proposals within a given area merit support relative to those in other areas, the Army will not award any contracts for that topic.

Phase I contracts are limited to a maximum of $100,000 over a period not to exceed six months.

Based upon progress achieved under a Phase I contract, a firm may be invited to propose Phase II. Any Phase II contracts following on Phase I proposals submitted under this solicitation will be limited to a maximum of $500,000 over a period of two years. Such Phase II activity will be structured as a single year contract with a one year option.

ARMY01-T001 TITLE: <u>Breathable Clothing Material for Chemical Agent Protection for the Soldier</u>

TECHNOLOGY AREAS: Materials/Processes, Human Systems

OBJECTIVE: Develop a semipermeable membrane coating for clothing that is a barrier to toxins, including chemical agents, while being permeable to water to provide the wearer comfort. This will be accomplished by preparing a permselective coating using reverse microemulsion technology to form a bicontinuous percolating microstructured system.

DESCRIPTION: Defense against weapons of mass destruction is a critical DoD requirement named by the Joint Chiefs of Staff as one of the Ten Future Warfighting Capabilities most needed by U.S. Combatant Commands. It is also critical for the civilian population for civil defense for an effective response in the event of a terrorist attack or an accident. An effective defense requires the development of unique clothing systems that are a physical barrier to toxic vapors, liquids, and aerosols. In addition, the protective material must be permeable to water to reduce incapacitating heat stress, and must be lightweight, flexible, and cost effective. Materials currently in use by DoD are effective barriers to chemical and biological weapons but they produce dangerous heat stress and are bulky, severely reducing maneuverability and the overall effectiveness of the wearer.

This topic will exploit recent research progress in the area of reverse microemulsion technology to solve these problems. This will be accomplished by forming a reverse microemulsion using polymerizable surfactants to produce clusters of water droplets to form a percolating microemulsion (ref. 1). The system will then be polymerized and crosslinked (ref. 2) to impart mechanical stability to form a material that may be tailored for selective permeation and barrier properties. The challenges include choosing materials that will polymerize without disrupting the microstructure (ref. 3) thus retaining permselectivity. Components such as isobutylene are likely candidates that can impart the desired barrier properties without compromising the microstructure. Further, an understanding of how these choices affect bulk properties needs to be fully developed. Although the scientific basis for generating such materials exists, no one has explored the system or application discussed in this topic.

PHASE I: Reverse microemulsions will be prepared using polymerizable surfactants to form coatings with clusters of water droplets creating a percolating microemulsion. In order for the material to be a barrier to toxic compounds, such as chemical agents, it is anticipated that the system will consist of components such as isobutylene or other similar compounds. The system will be polymerized and crosslinked to impart mechanical stability. Phase I will be proof of concept and focus on identifying components and preparing a percolating microemulsion that will produce a mechanically durable and flexible coating that is a barrier to toxic chemicals (chemical agent simulants are one example) while being permeable to water. The material will be characterized with respect to permeation and mechanical properties and the effect of polymerization of the system on these properties will be explored.

PHASE II: Phase II will focus on gaining a full understanding of how to tailor the materials to have targeted properties of interest to DoD and commercial markets. Areas to be explored include phase behavior, polymer molecular weights as a function of their effect on the microemulsion phase diagram, molecular weights as a function of initiator concentration, and the effect of polymerization on properties such as microstructure, permeation, and strength and toughness. In addition the process of coating materials of interest, such as cloth, will be characterized and optimized. During Phase II the investigators will collaborate with the Army to target specific properties and will prepare materials for evaluation by the Army Research Laboratory and the Natick Soldier Center.

PHASE III DUAL USE COMMERCIALIZATION: Materials that are comfortable to wear while protecting the wearer from toxins are critically important to law enforcement and fire fighters, including first responders to chemical and biological attack and chemical accidents. In addition the chemical industry, academe, and the healthcare industry would benefit from protection, such as gloves or full suits that protect against toxins while being breathable.

REFERENCES:
1. "Organic Microporous Materials Made by Bicontinuous Microemulsion Polymerization", J.H. Burban; M. He; E.L. Cussler, AIChE J. 41, 907, 1995.
2. "Polymerization of Tetrahydrofurfuryl Methacrylate in Three-Component Anionic Microemulsions", A.P. Full; J.E. Puig; L.U. Gron; E.W. Kaler; J.R. Minter; T.H. Mourey; J. Texter, Macromolecules, 25, 5157, 1992.
3. "Polymerization of the Inverted Hexagonal Phase", W. Srisiri; T.M. Sisson; D.F. O'Brien; K.M. McGrath; Y. Han; S.M. Gruner, J. Am. Chem. Soc. 119, 4866, 1997.

KEY WORDS: percutaneous protection, permselective membrane, chemical agents, reverse microemulsion, bicontinuous percolating microstructured systems

ARMY01-T002 TITLE: Ultraviolet/Infrared Detectors for Active Protection

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: To develop a multicolor detector/sensor that operates in both the solar blind, ultraviolet spectral region and the far infrared spectral region. This combination of spectral regions will enable detection and tracking of kinetic energy projectiles from the initial fire such that an active protection system can be enabled for the Army's Future Combat System.

DESCRIPTION: The Army's Future Combat System will forgo the heavy armor of current treaded vehicles and rely on an active response to avoid being hit by hostile fire. An important element of active protection is the ability to rapidly detect and track an incoming round such that the response system has sufficient time to respond. Over the past five years much improvement has been made in the area of uncooled infrared (IR) sensors as well as sensors in the ultraviolet (UV) spectral region. While a UV detector in the solar blind spectral region (230 – 290 nm) would be useful for active protection due to the lack of clutter in this region, fast photodetectors in a very wide spectral regions are critical here. For a kinetic energy fire, the round is frequently lost in the background of the blast, in both the visible and infrared (IR) spectral regions, but not in the UV region. On the other hand, the IR signal is useful in initial detection of a detonation. The objective of this STTR would be to develop low cost imaging devices that respond to both the IR and the UV. Because of the small time required to detect, track, and reply to an incoming round, it is desirable to have the UV and IR perfectly aligned to avoid time delays required for computational pixel registration. The UV and IR technologies would have to be integrated such that each pixel would be both a UV and IR detector. There are three major tasks involved in this project: 1) Research and fabrication of UV detectors in the solar blind spectral region; 2) research and fabrication of uncooled IR detectors; and 3) schemes to the integration and hybridization of the two detectors in a low cost device that will have the pixel by pixel registration mentioned above. One key to the integration, that may serve for low cost, is the ability to grow on Si substrates. This is a significant challenge in itself due to the large lattice mismatch for most UV detectors and silicon. However, some recently demonstrated progress and further anticipated university contributions should enable this area further. A low cost, dual color sensor with UV and IR spectral bands could become an important component for survivability in future, light weight, highly mobile, tanks and other tactical vehicles.

PHASE I: Determine requirements for active protection and demonstrate feasibility of integration of UV and IR, uncooled detectors.

PHASE II: Demonstrate system quality imaging in separate UV and IR bands. Develop a small imaging, dual color array with integrated pixels.

PHASE III DUAL USE COMMERCIALIZATION: Demonstrate large size (60,000 pixel) imaging array with UV and IR pixels. This detector sensor would also have military applications in general as well as strategic surveillance. Spinoffs from this development, separate UV and IR arrays, would have a plethora of uses including: general surveillance, navigation on the sea, night driving, product analysis, etc.

REFERENCES:
1. E. M. Gullikson, R. Korde, L. R. Canfield, and R. E. Vest, “Stable silicon photodiodes for absolute intensity measurements in the VUV and soft x-ray regions,” Journal of Electron Spectroscopy and Related Phenomena 80 (1996) 313-316.
2. E. Monroy, J. A. Garrido, E. Muñoz, I. Izpura, F. J. Sánchez, M. A. Sánchez-García, E. Calleja B. Beaumont, Pierre Gibart, “Characterization and Modeling of Photoconductive GaN Ultraviolet Detectors, MRS Internet J. Nitride Semicond. Res. 2, (1997) 12.
3. M.A. Johnson, Z.H. Yu, J.D. Brown, F.A. Koeck, N.A. El-Masry, H.S. Kong, J.A. Edmond, J.W. Cook, and J.F. Schetzina, “A Critical Comparison Between MOVPE and MBE Growth of III-V Nitride Semiconductor Materials for Optoelectronic Device Applications,” MRS Internet Journal of Nitride Semiconductor Research; 4S1(1999)G5.10.
4. G. Xu, X.M. Fang, P.J. McCann, Z. Shi, “MBE growth of wide band gap Pb1-xSrxSe on Si(111) substrate,” J. Crystal Growth, 209 (2000) 763-766.
5. W. Radford, M. Ray, R.H. Wyles, J. Wyles, J. Varesi, D. Murphy, a. Kennedy, K. Hay, and J. Finch, “High sensitivity 320x240 (25um pitch) microbolometer FPAs,” Proc. 1999 Meeting MSS Specialty Group on Infrared Detectors (1999) 367-376.

KEY WORDS: Uncooled infrared, ultraviolet detectors, solar blind

ARMY01-T003 TITLE: Bioluminescent/Integrated Circuits

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical, Electronics

OBJECTIVE: The objective of this topic is to develop a series of genetically engineered microbial tissue-based bioluminescent integrated circuits that will rapidly, quantitatively and selectively detect pathogenic agents such as Bacillus anthracis and Clostridium botulinum.

DESCRIPTION: This approach is based upon the hypothesis that the specificity of phage infection of bacteria can be used to identify, detect, or monitor particular bacterial species. These bioluminescent integrated circuits will be developed by incorporating, for example, bacteriophage-luxI constructs into microbial tissue-based biosensors that, when infected, will stimulate bioluminescence production from a second bacteriological reporter strain. The bacteriophage itself is metabolically inactive, only achieving replicative capabilities upon infection of its specific host bacteria. Since the phage lacks the intracellular machinery to process lux, they remain non-bioluminescent when the target species is absent. However, during a biological event, the phage genes with an accompanying lux construct will be taken up by the host bacterium and transcribed. This will result in an expression of the bioluminescent phenotype in proportion to the concentration of agent with which the tissue-based sensor comes in contact. Immobilization schemes will be developed to affix the engineered bioluminescent microbes to a silicone chip-based integrated circuit to amplify the bioluminescent signal and permit detection of pathogens in air, water, or soil. Sophisticated microelectronic circuitry will be developed and tested for remote monitoring of biosensor chips permitting the sensors to be distributed over large geographic areas to "map" pathogen location, distribution and intensity in real-time. University-based research in this area need be transitioned to an industrial research program.

PHASE I: Phase I will show proof of concept that such a phage infection is both selective for a bacterial species and can generate an appropriate signal. A biosensor based on this approach would consist of two elements; for example, a luxI integrated bacteriophage that specifically infects the pathogen of interest, and a lux-based bioluminescent cell line that responds to the infection event through quorum sensing bioluminescent signal stimulation. Choice of bioluminescent constructs is to be made by the proposer. Bacteriophage pathogen specificity will be used as a means of inducing bacterial tissue-based bioluminescence. The resultant bioluminescent tissue-based biosensor must be assessed for rapidity of response, sensitivity and selectivity of detection for selected pathogenic agents. The engineered bioluminescent cell line must be tested for determination of detection limits, response times, saturation kinetics, and basal expression levels of lux. Both temperate and virulent phage should be tested because it is unknown which phage type will generate optimal responses. Tests utilizing the engineered bioluminescent strain in conjunction with varying concentrations of luxI bacteriophage and associated pathogen will be performed to determine detection limits, response times, saturation kinetics, and background induction.

PHASE II: To adapt bioluminescent integrated circuit technology to wide area biological agent monitoring a single microchip application-specific integrated circuit (ASIC) optical transducer will be developed and produced that couples directly to bioluminescent biosensor matrices to provide a complete, stand-alone detection system. The bioluminescent biosensor whole-cell matrix will be housed in a light tight, metabolically supportive matrix that promotes analyte/biomatrix interaction. The housing must also prevent release of the engineered microbes into the environment. Sensor packaging strategies should be applied to provide for reliable, long term operation of the micro-chip based biologically-active sensing platform in diverse matrices such as air, soil or water.

PHASE III DUAL USE COMMERCIALIZATION: The bioluminescent integrated circuits can be modified and customized to serve as a dual use technology in a diverse number of detection applications. The integrated circuitry permits creation of remotely transmitting distributed networks that can delineate the spread and intensity of biological agents over large geographic areas or provide for placement at critical points in food processing establishments.

REFERENCES:
1. Applegate, B.M., Shingleton, J., Ripp, N., Bright, D., Nivens, D., Simpson, M. and Saylor, G. In: Bioluminescence and Chemiluminescence Perspectives for the 21st Century, A. Roda, M. Pazzagli, L. Kricka and P. Stanley (Editors), 1999.
2. Layton, A.C., Gregory, B., Schultz, T.W. and Saylor, G.S. Ecotox. Environ. Safety, 1999, 43, 222-228.

KEYWORDS: Chemical and Biological Defense, Microsensors, Biosensors, Integrated Circuits, Bioluminescence

ARMY01-T004 TITLE: Remote Sensing and Directed Energy Applications of Femtosecond, Terawatt Lasers.

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors, Electronics, Weapons

OBJECTIVE: Recent experiments have shown that terawatt, femtosecond laser pulses can propagate up to 12 km in the air. This constitutes a several order of magnitude increase in the propagation distance for high power lasers. The large distance makes possible the development of a new type of remote LIDAR (Light Detection And Ranging) system for the detection of biological and chemical agents at far distances. In addition, these pulses may initiate damage in sensor devices, which could be implemented as counter measures. With current technology, such laser systems can be made compact and man-portable to be used in the field. However, the long-range propagation phenomenon, which involves the rapid dynamics of the strong interaction of the laser field with the atmosphere, is very new and the underlying physics is not well understood. In order to appropriately tailor and control the propagation, a theoretical physics program is needed for the development of a model that quantitatively describes the phenomenon. In addition, the model needs to be verified both with existing data, and also through experiments directly supporting the above applications.

DESCRIPTION: The long-range propagation in air of intense (~10 GW/cm2), short (<200 fsec) pulses has been a subject of significant interest since its discovery about five years ago. The laser beam self-focuses to a few hundred micrometers in diameter and maintains its power density and temporal structure over long distances. The stable self-channeling prevents optical breakdown. In addition, the strong self-phase modulation produces spectral broadening from the near-UV through the near-IR, and the spectrum exhibits a high, nearly invariant, degree of spectral coherence. Thus, the term "white light laser" has been coined. Because of the high intensity and large propagation distance, the phenomena has great and versatile potential as a novel white light LIDAR and sensor countermeasure. A key aspect of the phenomena is the formation of individual filaments as the initial pulse power is increased beyond a threshold value. The optical filament can form a tight bundle that propagates over long distances. To control the propagation, it is necessary to understand the filamentation and propagation physics in terms of system parameters and initial and boundary conditions.

PHASE I: Develop a physics based numerical and analytical propagation model that includes the strong interaction of the laser pulse with the medium. This should include a verifiable analysis of the detailed transverse instabilities, filamentation, coherence and beam pointing fluctuations as a function of initial conditions such as pulse width, beam radius, wave-front divergence and frequency chirp.

PHASE II: Utilize the understanding of the long-range spatial-temporal dynamical evolution and phase coherence to experimentally demonstrate the applicability of the phenomenon to sensor countermeasures and to remote sensing of chemical and biological agents.

PHASE III DUAL USE APPLICATIONS: The resulting model and experimental verification will serve as the foundation for novel LIDAR systems for remote detection of atmospheric chemicals and aerosols for pollution monitoring, and for the remote measurements of atmospheric turbulence for improved wind-shear alerts for landing aircraft.

REFERENCES:
1. N. Akozbek, C. Bowden, A. Talepour and S. Chin, Phys. Rev. E 61, 4540 (2000).
2. N. Akozbek, C. Bowden, A. Talepour and S. Chin, Laser Physics, 10, 101 (2000).

3. A. Braun, G. Korn, X. Liu, D. Du, J. Squier, and G. Mourou, Opt. Lett. 20, 73 (1995).
4. Uwe Brinkmann, Laser Focus World, 35, November (1999).

KEY WORDS: Long-range femtosecond laser propagation; ultrashort laser pulse propagation; white-light laser; remote chemical/biological agent detection

ARMY01-T005 TITLE: Bioengineered Proteins for Chemical/Biological Defense, Protection, and Decontamination

TECHNOLOGY AREAS: Chemical/Bio Defense, Human Systems

OBJECTIVE: To develop an innovative, very high yield system for the production of unmodified recombinant proteins for use in chemical/biological (CB) decontamination and protection regimens, CB detection devices, and in the production of specially bioengineered protein-based materials for applications in bioinformatics, nanostructures, etc.

DESCRIPTION: Numerous applications are being developed for proteins that have been engineered for specific biological or physical properties. The specificity of enzyme proteins in destroying or modifying various CB threats make them ideal choices for utilization in detection, protection, and decontamination devices. While the versatility and utility of such proteins is widely recognized, there are severe constraints in the production of the genetically modified proteins. Most protein production systems currently use laboratory “friendly” organisms that were selected not because of their utility in scaled-up fermentation processes but because they were convenient organisms for which there was much laboratory experience in their genetic and growth characterizations. This STTR seeks innovative and creative approaches to develop a high yield gene expression system that would allow the production of abundant amounts of bioengineered proteins under simple and comparatively inexpensive culturing conditions. This would generate adequate supplies of specialized proteins for utilization in CB defense and in the construction of protein-based biomaterials.

PHASE I: This effort will focus on the analysis of systems that have the capabilities for producing high levels of proteins under minimal growth conditions in industrial-scale fermentations; e.g., yeast, fungi, bacteria, plants, and animal cultures. A successful Phase I will investigate and demonstrate approaches in the university and small business community that could be used for producing high protein yields and genetic constructions for recombinant proteins into those organisms. Protein yields, stability of the introduced genes, ease of preparation of proteins and cost of production of the proteins would all be factors to determine a suitable high-volume recombinant gene expression system.

PHASE II: The small business should implement the scale-up of the culture system and yields of model recombinant proteins. Calculations of the cost of the high-yield proteins should be made to affirm the utility of the model system. Recommendations for the optimal cultural conditions should also be made.

PHASE III DUAL USE APPLICATIONS: The system to be developed would significantly impact the development of devices for CB and nanotechnological applications and biomaterials for military applications, as well as a myriad of civilian, industrial and medical applications. Proteins that could be produced by the system include organophosphate-degrading enzymes for protection and decontamination, biochemical sensors, and very high purity blood proteins for remediating massive exsanguination.

OPERATION AND SUPPORT COST (OSCR) REDUCTION: Operating and Support Costs (O&S) would be favorably impacted by this technology. A high-yield fermentation for bioengineered proteins would allow the current protein-based systems to be replaced by cheaper and more efficient protein expression systems. Furthermore, with the availability of abundant amounts of genetically modified proteins numerous other military and civilian applications would be accelerated.

REFERENCES:
1. Rozkov, A., and Envors, S-O. 1999. Stabilization of a proteolytically sensitive cytoplasmic recombinant protein during transition to downstream processing. Biotechnol. Bioeng. 62, 730-738.
2. Mukhopadhyay, A. 1997. Inclusion bodies and purification of proteins in biologically active form. Adv. Biochem. Eng./Biotechnol. 56, 61-109.
3. Vieth, W.R. 1994 Bioprocess engineering. J. Wiley and Sons.
4. Shuler, M.L., and Kargi, F. 1992. Bioprocess engineering. Prentice Hall.

KEYWORDS: Microbial high-yield protein systems; bioengineered proteins; recombinant proteins; protein purification.

ARMY01-T006 TITLE: Multiband Fluorescence Imaging for Wide Area Detection of Land Mines, Unexploded Ordnances, and Other Contaminants

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors, Battlespace

OBJECTIVE: Airborne Real-time Detection of Unexploded Ordnance/TNT Contaminated Areas by Enhanced Multiband Fluorescence Imaging.

DESCRIPTION: The detection of unexploded ordnance (UXO) and land mines is a major concern for ground forces. In addition, mandated clean up and reclamation of military bases requires a robust method to detect contaminants related to buried UXO material. Recent laboratory testing has shown that laser-induced fluorescence technology was successful in the detection of fluorescence emissions related to secondary explosives (i.e., TNT), where photoluminescence was enhanced through the use of genetically engineered microbes. A multiband fluorescence imaging system incorporating specific broad-band excitation and emission capabilities could expand the utility of the technology and broaden the range of detectable UXO constituents including metals-based primary explosives, and other target materials. It is envisioned that a fully operational system will be aircraft mounted for use over large, potentially hazardous areas.

PHASE I: Demonstrate the feasibility of using fluorescence information to enable detection of TNT, UXO, or other contaminants. Possible excitation sources could include, but is not limited to, lasers, flashlamps, and solar energy (through use of Fraunhofer lines). The fluorescence signal may be enhanced/modified by (again not limited to), microbes, vegetation, polymers, and chemical compounds. Investigate parameters such as target material uptake/reaction time, optimal excitation wavelength, fluorescence signal strength, and spectral separation from backgrounds.

PHASE II: Develop a “benchtop” prototype system, including excitation source, fluorescence enhancing material (i.e., microbes, vegetation, etc.), and detection hardware. Demonstrate, through laboratory and limited field testing, that the fluorescence signal obtained from the desired material is detectable and separable from background features. Identify and address system scaling issues that will allow for the transition of this technology to an airborne platform.

PHASE III DUAL USE COMMERCIALIZATION: Develop a prototype airborne delivery and detection system capable of covering approximately 100 acres per day/night. Conduct testing to prove the feasibility of using this system in multiple environments. Develop a prototype hardware and software system to perform image processing, mosaic construction, signature matching, and Geographic Information Systems (GIS) overlays.

It is envisioned that multiple civilian/commercial uses of this technology exist. An airborne fluorescence imaging system (especially in combination with enhanced fluorescence techniques) could be applied towards industrial waste (e.g. heavy metals, toxins, etc.), detection, mapping, and cleanup. Possible additional uses could include detection of chemical/biological weapons byproducts, agricultural monitoring, and both aquatic and terrestrial petroleum spills.

REFERENCES:
1. Fischer, R.L., R.S. Burlage, J. DiBenedetto, and M.J. Maston. 2000. Using Fluorescence Imagery and Microbes for Ordnance and Mine Detection. Army AL&T, PB-70-00-4, 10-12.
2. Burlage, R.S., R.L. Fischer, J. DiBenedetto, and M.J. Maston. 2000. Reporter Gene System for the Field Detection of Explosives. Second International Symposium on Biotechnology for Conservation of the Environment, July 9-12, 2000, Munster Germany.

KEY WORDS: TNT, UXO, land mines, laser induced fluorescence, spectral signatures

ARMY01-T007 TITLE: Telemedicine and Advanced Medical Technology - Medical/Surgical, Mission Support Modeling, and Simulation

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: To advance develop and demonstrate a computer-based, central venous catheterization (CVC) simulation system for training of military far-forward care providers and emergency responders. The implementation of this technology should enable the Department of Defense (DoD) to provide improved medical support to the wounded soldier through enhanced medical training with improved diagnosis, rehearsal, and treatment planning. The CVC system falls into a category of “virtual workbench” type simulators currently sought by DoD medical trainers

DESCRIPTION: Objective force concepts of operation require sustenance and enhancement of the quality of medical care, which includes ensuring the currency of the skills of medical care providers. Thus, there is a need to develop a CVC simulation system to provide the visual and tactile fidelity necessary for combat care training. The objective of creating a computer simulated virtual environment for medical training is to provide a level of training not possible using traditional methods. Traditional techniques for teaching trauma procedures have depended largely on the existence of a sufficiently large number of proctors with adequate skills to teach trauma procedures. Other approaches include practice on animals, but animal models of injury often do not reflect human trauma, and raise a host of ethical issues concerning procuring and maintaining animals for training. Also, practice on humans and animals precludes the ability to repeatedly rehearse specific components of the procedure that may prove challenging or require finely tuned motor skills. An additional concern is that Department of Defense (DoD) hospitals are usually not regional trauma centers, so that physicians and allied health personnel in the military may not obtain significant exposure to human trauma cases for training purposes.

PHASE I: Describe concept and design a realistic advanced prototype of a CVC Simulation system, based on a complete task analysis to be conducted. All technical components for CVC simulation have demonstrated feasibility, including:

1. Development of a prototype haptic feedback interface device
2. Refinement in computer modeling technology
3. Development of educational content design document
4. Medical Simulation Software Architecture

The development of a haptic feedback interface device is critical to a realistic medical simulation. A device to simulate the needle stick, vein location, and catheter navigation has been designed and prototyped but requires field evaluation. Significant refinement is needed in computer modeling technology for internal jugular and femoral vein central venous access. The need for development of educational content includes skin stretch via the interaction device, patient feedback (pain sounds, hematoma, etc.), and "drag and drop" application of, for example, topical application of antiseptics and anesthetics. Hardware and software developmental needs include a second generation device that will accept the longer central line used in CVC and .the design of a CVC module that can be used for training, skills maintenance, and measurable quality improvement.

PHASE II: Develop and demonstrate a functional prototype of a full performance CVC simulation system. These efforts should include: a) development of a prototype haptic feedback interface device; b) refinement in computer modeling technology; c) development of educational content design document; and d) development of medical simulation software architecture.

PHASE III DUAL USE COMMERCIALIZATION: This CVC simulation system is applicable to military and civilian tactile task training. Additionally the CVC simulation workstation system will be a powerful intermediate in the path toward Total Immersive Virtual Reality training.

REFERENCES: "Operational Capability Elements: Joint Medical Readiness," Page 6 (section 3.2.1), Joint Science and Technology Plan for Telemedicine (submitted to and approved by the DDR&E, 1 October 1997) - Chapter IV (section F), Joint Warfighting Science and Technology Plan (1997)

KEY WORDS: Modeling and simulation, medical skills training, individual and unit training, medical force readiness, mission rehearsal, CVC simulation, haptics, force feedback, tactile training.

ARMY01-T008 TITLE: <u>Novel Assessment Tools for Empirical Determinants of Direct Leadership</u>

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: To create novel assessment tools and new empirical technologies for determining all sources of direct leadership effectiveness in a real world setting.

DESCRIPTION: Bold, innovative leaders of character and competence are fundamental to the long-term health of the Army. In the Objective Force of 2015-2020, relatively junior leaders will be faced with a much broader scope of responsibilities than has been true in the past. Companies may be deployed on their own, and company commanders will therefore need to be able to command on their own. At all levels in the Army we will need bold, innovative leaders with the skills and ability to do things right and the knowledge, wisdom, maturity, values, and judgment to do the right thing. But especially at lower levels, we will need to develop these leaders very quickly, and then provide the safety net to support them as they face their daunting challenges. The key to the development of direct leadership capabilities is the ability to measure leadership behavior in an objective fashion and ultimately to relate it to predictive personnel attributes, how they change with experience, and how easy or difficult they are to change. New internet based technologies for communicating, sharing experiences and decisions, and analyzing complex text databases provide novel approaches to observing leadership decision making and performance in the field. To begin the effort of creating novel assessment tools for measuring leadership development, the Army Research Institute (ARI) and the United States Military Academy (USMA) created a Baseline Officer Longitudinal Data Set (BOLDS) in which cadets were tracked over the course of their 4-year USMA developmental experience on multiple instruments and performance ratings. (c.f. http:///www.dean.usma.edu/bsl/bolds.htm). Results from this database will be made available to the researchers to assist their development of new empirical measures of actual leadership performance in the field. However, now that these officers have moved into the field, novel assessment tools for measuring leadership performance must be developed, using new technologies arising from the internet and new psychological theories of emotional intelligence and tacit knowledge, that go beyond paper and pencil tests. The purpose of this new effort will be to create and validate empirical technologies for objectively measuring and assessing the direct leadership effectiveness of officers as they progress through early leadership experiences in the Army. From this, an overarching framework will be created for understanding and developing leadership in many different military and industrial settings.

PHASE I: Develop a battery of novel, objective, direct leadership assessment tools that can be applied in a real world setting and justify them using an acceptable theoretical framework. This battery must provide for direct predictions of performance that can be observed and measured in junior officer leadership positions at the level of Army squad, platoon, company, or battery. It must incorporate new technologies for collecting and observing leadership performance directly, provide for sharing experiences and communication on internet sites like www.Companycommand.com and www.Platooncommand.org, and be capable of sophisticated text analysis of such communication. It must also incorporate the latest psychological insights into leadership attributes, such as emotional intelligence and tacit knowledge. The Phase I proposal must describe in detail the approach to the creation of this novel assessment tool battery, the development of a sampling plan and kinds of data to be collected to accurately describe the leadership effectiveness of individual officers in the field. The range of influences to be incorporated into the framework and of the data to be collected with the set of novel assessment tools shall include at a minimum individual characteristics, interpersonal skills and behavior, organizational characteristics and behavior, and led-unit outcome measures.

PHASE II: Using the planning and theoretical products of Phase I, develop the full battery and validate its development using an Army population to be selected by ARI.

PHASE III DUAL USE COMMERCIALIZATION: Accurately measuring the determinants and all sources of direct leadership effectiveness through novel assessment tools has broad potential use throughout DoD military and civilian organizations; in every sort of industry; and in a broad array of occupations from teachers and school principals to chief executive officers of commercial enterprises.

REFERENCES:
1. Bartone, P.T. (1999). Hardiness protects against war-related stress in Army
reserve forces. Consulting Psychology Journal, 51 (2), 72-82.
2. Goleman, D. (1998) Working with emotional intelligence. New York: Bantam Books.
3. Sternberg, R.J., Forsythe, G.B., Hedlund, J., Horvath, J. A., Wagner, R.K., Williams, W.M., Snook, S., & Grigorenko, E.L. (2000). Practical intelligence in everyday life. New York: Cambridge University Press.
4. Zaccaro, S. J., Klimoski, R. J., Boyce, L. A., Chandler, C., & Banks, D. J. (1999). Developing a toolkit for the assessment of Army leadership processes and outcomes: Version 1.0 (ARI Research Note 99-35). Alexandria, VA: U.S. Research Institute for the Behavioral and Social Sciences. (DTIC Number AD A368).

KEY WORDS: Direct Leadership; 360 Assessment; Command Climate; Lieutenants; Captains; Platoons; Company; Personality; Knowledge; Skills; Tacit Knowledge; Hardiness; Commitment; Azimuth; Problem Solving; Interpersonal Skills; Baseline Officer Longitudinal Data Set (BOLDS); Emotional Intelligence.

ARMY01-T009 TITLE: High Resolution Electromagnetic and Thermal Mapping of Radio Frequency Components

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

OBJECTIVE: To provide the capability to map the transient electromagnetic near field around large, complex radio frequency (RF) circuits, in correlation with the transient temperature field, in order to obtain knowledge about the actual circuit interactions for purposes of physical understanding of the complex circuit interactions, design information, and diagnostic indications.

DESCRIPTION: As RF circuits become more complex, with electromagnetic structures such as antenna elements, filters, inductors, etc., closely integrated with nonlinear, active devices such as diodes and transistors, the coupling of the active devices through unanticipated electromagnetic paths has become a serious design problem. This is particularly true for large active antenna arrays found in spatially or quasi-optically combined systems. In addition, RF power circuits are beginning to show that the temperature variation across a circuit can have a large effect on performance, not only at relatively long time scales, but in some cases at time scales which cause interference with the baseband modulation frequency band. Recent government sponsored university research has demonstrated highly effective electromagnetic mapping approaches using a variety of electro-optic and microwave techniques. By itself this EM mapping of the operating circuit has played a critical role in understanding the physical processes occurring in complex RF structures and in diagnosing circuit problems. Other government sponsored university research has demonstrated the effectiveness of thermal mapping of RF circuits in operation in diagnosing device and circuit behavior as revealed by the time dependence of temperature differences at high resolution. (See the references below for examples). The ability to correlate the information from the time dependence of the near EM field with the transient temperature distribution, at high resolution across the RF circuit, is expected to provide a new level of circuit understanding and design information. The electromagnetic imaging would be required at finer resolution than a wavelength for circuits operating from hundreds of MHz to 100 GHz. The electromagnetic field must be imaged in all 3 vector components and in amplitude and phase. The thermal imaging must be capable of the same or finer resolution than the electromagnetic imaging. The electromagnetic probe should be noninvasive, and both the thermal and electromagnetic imaging systems must not interfere with each other. The system must be capable of imaging large arrays of antenna elements integrated directly with active devices and circuits as well as smaller, but complex RF circuits. The university contribution is to provide the research expertise in the fields of the mapping technology and the interpretation of the mapped images, to configure a laboratory prototype to provide a model for commercial implementation, and to provide the interpretation of correlated imaging results and algorithms to use in the commercial diagnostic software.

PHASE I: Demonstrate the feasibility of the combined EM and thermal transient imaging capability and show what new types of circuit phenomena can be inferred from the resulting data.

PHASE II: Design a system demonstration for testing which is appropriate as a basis to commercialize a cost effective, marketable system for commercial and military applications.

PHASE III DUAL USE COMMERCIALIZATION: Such a unique RF circuit diagnostic tool will directly impact the product cost and size of RF systems by enabling the characterization of early design concepts, the fast identification of design problems, and the high resolution determination of circuit areas requiring reduced RF component separation (resulting in denser circuit layout). This will impact commercial cellular electronics, radar, and millimeter wave communications and target acquisition systems, military and commercial. The product to be marketed is the diagnostic mapping tool itself, with the potential market being companies designing RF products and systems.

REFERENCES:
1. K. Yang, L.P.B. Katehi, and J.F. Whitaker, "Electro-optic field mapping system utilizing external gallium arsenide probes," Appl. Phys. Lett., vol. 77, pp. 486-488 (Jul. 2000)
2. E.C. Landahl, et. al., “Phase Noise Reduction and Photoelectron Acceleration in a High Q RF Gun, IEEE Trans. on Plasma Science, vol. 26, no. 3 (Jun 1998)
3. R.G. Johnson, W. Batty, A.J. Panks, and C.M. Snowden, “Fully Physical Coupled Electro-Thermal Simulations and Measurements of Power FET’s,” in 2000 IEEE MTT-S International Microwave Symposium Digest, pp. 461-464,
4. T.P. Budka, S.D. Waclawik, and G.M. Rebeiz, “Near Electric Field Mapping Above X-Band MMIC’s Using Modulated Scattering,” IEEE MTT-S International Microwave Symposium Digest 1997, pp1703-1706.

KEY WORDS: Near field electromagnetic imaging, thermal circuit imaging, Radio Frequency circuit diagnostics.